NOTES ON FLEAS COLLECTED IN THE PROVINCES OF NOORD-BRABANT AND LIMBURG, THE NETHERLANDS (SIPHONAPTERA)

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ABSTRACT

Twenty three species (954 specimens) of mammal fleas and two species (12 specimens) of bird fleas were taken from 19 species (336 specimens, 174 infested) of mammals. Nine species (2997 specimens) of bird fleas and five species (13 specimens) of mammal fleas were reared from 204 nests (77 infested) of 45 species of birds. All material was collected in the provinces of Noord-Brabant and Limburg, The Netherlands, in 1964.

Fifteen mammal fleas and five bird fleas were found to be new to Noord-Brabant and two mammal fleas and four bird fleas were new to Limburg. Thirteen species of birds and two mammals were added to SMIT's list of hosts for Dutch fleas (SMIT, F. G. A. M., 1962. "Catalogus der Nederlandse Siphonaptera". *Tijdschr. Ent.* 105 : 45—96, fig. 1—8). New flea-host-associations were ound for 25 flea hosts recorded by SMIT.

The ecology, host and nest specificity, sex ratios and economic importance of fleas are discussed.

Mammal fleas and bird fleas are dealt with separately under their relevant hosts or their nests.

In a synopsis the geographical distribution of all fleas recorded from The Netherlands so far is indicated.

INTRODUCTION

In this paper, which is meant primarily as a report on Siphonaptera collected from mammals and birds' nests taken in the provinces of Noord-Brabant and Limburg, The Netherlands, some *obiter dicta* will also be devoted to host and nest specificity, ecology, sex ratios and economic importance of the fleas recorded, while a synopsis of Dutch fleas and their distribution over provinces will be incorporated in the text.

SMIT (1962a) enumerated 50 species and subspecies of fleas recorded from The Netherlands. Of these 39 are mammal parasites and the remainder have avian hosts. These figures compare well with those for the British Isles whence 16 bird fleas and 40 mammal fleas have been recorded (SMIT, 1957b) and with those known from Denmark where of 53 species and subspecies of fleas recorded by SMIT (1954), 13 are parasitic on birds. The bird flea fauna of Ireland consists of 13 species and subspecies of bird fleas and only 22 mammal fleas (CLAASSENS & O'ROURKE, 1965).

The number of bird fleas occurring in mentioned countries is high as compared with a total of about 100 bird fleas known to occur in the world while the total of described species and subspecies of fleas amounts to nearly 1800.

The difference in the number of bird fleas in the four countries may be due partly to insufficient study, but must also be accounted for by the difference in ecological requirements of some host specific fleas. The species *Ornithopsylla laetitiae* Rothschild, occurring on Manx shearwater, *Procellaria puffinus puffinus* Brünnich, and the puffin, *Fratercula arctica grabae* (Brehm), has so far only been recorded from the isles west of the coast of England and Wales, and off the coast of Ireland (SMIT, 1957b). The house-martin fleas, *Frontopsylla (Orfrontia) laeta* (Jordan & Rothschild) and *Callopsylla (Orneacus) waterstoni* (Jordan), have been recorded only from nests of cliff building house-martins, *Delichon urbica* (Linnaeus), in Scotland (ALLAN, 1950; SMIT, 1952), and in Ireland (CLAASSENS, 1965a and 1965b). They are further known from Switzerland and the Caucasus (SMIT, 1957a), where they have a very limited recorded distribution.

The relatively poor representation of mammal fleas in these countries is due to the scarcity of mammalian host species. The bird fauna in the same countries is much richer and hence bird fleas have access to a great diversity of hosts and nesting sites, two ecological requirements necessary for different species of fleas to thrive under the given climatic and geological conditions. Phylogenetically, bird fleas are derived from mammal fleas and this secondary evolution together with the wide distribution of many birds may be responsible for the catholic tendencies among bird fleas as regards their adaptive radiation, host specificity and geographical distribution.

Although bird fleas show a lesser degree of monoxenous parasitism than mammal fleas, some are restricted to definite hosts or their nests, but it is difficult to determine, in most cases, whether the nest, or the host in providing the nest, lies at the root of this predilection.

Until 1962 only four bird fleas and eight mammal fleas were recorded from Noord-Brabant (SMIT, 1962a). The fleas of Limburg were fairly well known by that time, especially the bat fleas for the study of which the southern part of this province offers a unique opportunity. Moreover, this part of the country has many geological, floral and faunal peculiarities all of which of necessity lure naturalists of all kind to visit it and discover its secrets.

From the many mammals and birds' nests collected mainly during the months of October, November and December, 1964, the author recovered 23 species of mammal fleas and nine species of bird fleas. Records of 15 mammalian and five bird fleas were found to be new to Noord-Brabant and two of the former and four of the latter were new to Limburg. In the following synopsis of the recorded Dutch fleas all provinces from which a species was reported are given, while the provinces from which new records were made by the author, are marked with an asteric. The abbreviations used for the provinces and islands are as follows: G. = Groningen; F. = Friesland; D. = Drente; O. = Overijsel; Gld. = Gelderland; U. = Utrecht; NH. = Noord-Holland; ZH. = Zuid-Holland; Z. = Zeeland; NB. = Noord-Brabant; L. = Limburg; T. = Texel; V. = Vlieland; Ts. = Terschelling; A. = Ameland; S. = Schiermonnikoog; R. = Rottum.

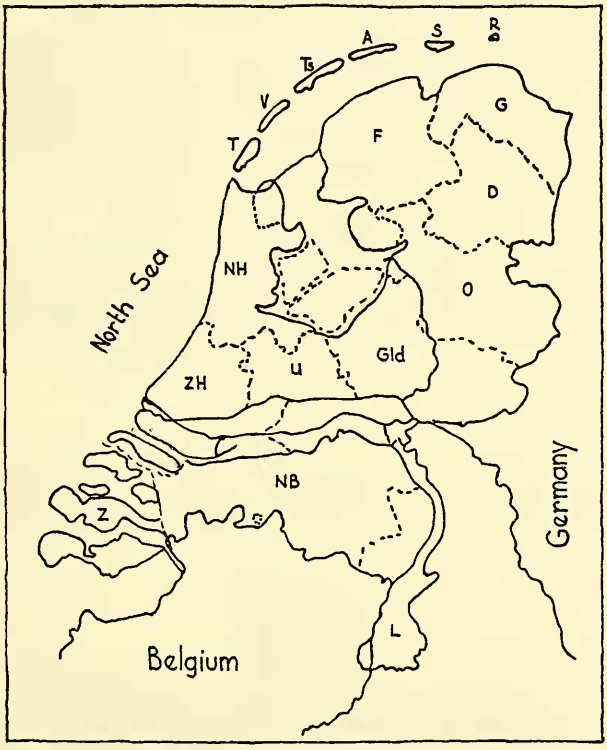
For the exact geographic position of the localities within the provinces from where fleas were recorded, see SMIT (1962a) on whose paper this synopsis is based and whose classification and nomenclature of Siphonaptera are used. The

geographical position of the provinces and islands of The Netherlands is shown in figure.

We collected fleas from the following localities.

Noord-Brabant: Beers, 51.43 N. 5.52 E; Boxtel, 51.35 N 5.20 E; Cuyk, 51.43 N 5.53 E; Goirle, 51.31 N 5.04 E; Grave, 51.45 N 5.46 E; Loon op Zand, 51.38 N 5.05 E; Mill, 51.41 N 5.49 E; Oisterwijk, 51.35 N 5.12 E; Schayk, 51.44 N 5.28 E; St. Hubert, 51.40 N 5.50 E; St. Michiels Gestel, 51.38 N 5.21 E; Strabrechtsche heide, 51.25 N 5.39 E; Tilburg, 51.33 N 5.07 E; Vught, 51.39 N 5.18 E; Wanroy, 51.39 N 5.49 E.

Limburg: Schinnen, 50.57 N 5.53 E; Venlo, 51.22 N 6.10 E; Venray, 51.32 N 5.58 E.



Provinces and islands of The Netherlands

SYNOPSIS OF THE KNOWN DISTRIBUTION OF DUTCH FLEAS

Hystrichopsyllidae

Hystrichopsyllinae

Hystrichopsylla (Hystrichopsylla) talpae talpae (Curtis, 1826), F. O. Gld. U. NH. ZH. Z. NB. L.

Typhloceras poppei Wagner, 1903, F. Gld. U. NH. *NB. L.

Doratopsyllinae

Doratopsylla dasycnema dasycnema (Rothschild, 1897), Gld. *NB. *L. Ts.

Ctenophthalminae

Palaeopsylla soricis soricis (Dale, 1878), F. O. Gld. U. ZH. *NB. L. Ts.
Palaeopsylla minor (Dale, 1878), F. O. Gld. U. NH. ZH. Z. NB. L.
Ctenophthalmus (Ctenophthalmus) bisoctodentatus heselhausi (Oudemans, 1914), G. O. Gld. NH. ZH. Z. NB. L.
Ctenophthalmus (Ctenophthalmus) agyrtes agyrtes (Heller, 1896), G. F. D. O. Gld. T. Ts. S.
Ctenophthalmus (Ctenophthalmus) agyrtes smitianus Peus, 1950, Gld. U. NH. ZH. Z. NB. L.
Ctenophthalmus (Euctenophthalmus) assimilis (Taschenberg, 1880), G. F. Gld. U. NH. ZH. Z. *NB. L.
Ctenophthalmus (Euctenophthalmus) congener congener Rothschild, 1907, G. O. Gld. *NB. L.

Rhadinopsyllinae

Rhadinopsylla (Actenophthalmus) pentacantha (Rothschild, 1897), F. *NB. L.
Rhadinopsylla (Actenophthalmus) isacantha continentalis Smit, 1957, Gld.

LEPTOPSYLLIDAE

Leptopsyllinae

Leptopsylla segnis (Schönherr, 1811), G. F. Gld. U. NH. ZH. *NB. L
Peromyscopsylla silvatica (Meinert, 1896), Gld. *NB. *L.

ISCHNOPSYLLIDAE

Ischnopsyllinae

Ischnopsyllus (Ischnopsyllus) elongatus (Curtis, 1832), Gld. NH. ZH. *NB.
Ischnopsyllus (Ischnopsyllus) intermedius (Rothschild, 1898), F. O. NH. ZH. L.
Ischnopsyllus (Ischnopsyllus) octactenus (Kolenati, 1856), Gld. U. NH. ZH. *NB. L.
Ischnopsyllus (Ischnopsyllus) simplex simplex Rothschild, 1906, L.
Ischnopsyllus (Ischnopsyllus) simplex myticus Jordan, 1942, L.
Ischnopsyllus (Ischnopsyllus) variabilis (Wagner, 1898), L.
Ischnopsyllus (Hexactenopsylla) hexactenus (Kolenati, 1956), G. Gld. U. ZH. *NB. L.
Rhinolophopsylla unipectinata unipectinata (Taschenberg, 1880), L.
Nycteridopsylla eusarca Dampf, 1908, Gld.
Nycteridopsylla longiceps Rothschild, 1908, U. ZH. L.
Nycteridopsylla pentactena (Kolenati, 1856), O. Gld. U. ZH. L.

Ceratophyllidae

Ceratophyllinae

Paraceras melis melis (Walker, 1856), Gld.
Tarsopsylla octodecimdentata octodecimdentata (Kolenati, 1863), O. Gld.
Dasypsyllus gallinulae gallinulae (Dale, 1878), Gld. NH. ZH. NB. L.
Nosopsyllus fasciatus (Bosc, 1800), G. F. Gld. U. NH. ZH. NB. L.
Malaraeus (Amalaraeus) penicilliger mustelae (Dale, 1878), Gld.
Megabothris turbidus (Rothschild, 1909), G. F. D. O. Gld. ZH. *NB. L.
Megabothris walkeri (Rothschild, 1902), Gld.
Monopsyllus sciurorum sciurorum (Schrank, 1803), D. O. Gld. U. NH. ZH. NB. L.
Ceratophyllus hirundinis (Curtis, 1826), G. Gld. NH. ZH. Z. *NB. *L.
Ceratophyllus rusticus Wagner, 1903, G. NH. Z. *NB. *L.
Ceratophyllus farreni farreni Rothschild, 1905, G. Gld. NH. Z. *NB. *L.
Ceratophyllus styx styx Rothschild, 1900, F. O. NB. L.
Ceratophyllus gallinae gallinae (Schränk, 1803), F. D. O. Gld. U. NH. ZH. Z. NB. L.
Ceratophyllus fringillae (Walker, 1856), Gld. NH. ZH. Z. *NB. L.
Ceratophyllus rossittensis rossittensis Dampf, 1903, NH.
Ceratophyllus columbae (Gervais, 1844), Gld. NH. ZH. *NB. L.
Ceratophyllus garei Rothschild, 1902, Gld. NH. ZH. NB. Z. *L.
Ceratophyllus borealis Rothschild, 1907, ZH.

Vermipsyllidae

Chaetopsylla (Chaetopsylla) globiceps (Taschenberg, 1880), Gld. L.
Chaetopsylla (Chaetopsylla) trichosa Kohaut, 1903, Gld. L.

Pulicidae

Spilopsyllinae

Spilopsyllus cuniculi (Dale, 1878), D. O. Gld. U. NH. ZH. *NB. L.

Archaeopsyllinae

Ctenocephalides canis (Curtis, 1826), Gld. U. NH. ZH. *NB. L. Ts.
Ctenocephalides felis felis (Bouché, 1835), O. Gld. U. NH. ZH. *NB. L. Ts.
Archaeopsylla erinacei erinacei (Bouché, 1835), Gld. U. NH. ZH. Z. NB. L.

Pulicinae

Pulex irritans Linnaeus, 1758, F. O. Gld. U. NH. ZH. NB. L. Ts.

MATERIAL AND METHODS

Trapping of mice, voles and shrews was done with eight live traps constructed of wire netting which, though very efficient for catching small mammals proved less dependable as regards keeping the animals alive. All traps were baited with cheese and checked every morning from October 4th until December 15th, 1964. Six traps made of wood were used in our house and garden. These were also baited with cheese and checked at regular intervals every day from June 15th until December 15th, 1964. All animals trapped in and near our house were collected alive. Three pygmy shrews, *Sorex minutus* Linnaeus, and one common shrew, *Sorex araneus* Linnaeus, were captured in jars used as pitfalls at Koningshoeven, Tilburg.

All catches dead or live were put in separate polythene bags and, if necessary, killed from the outside before they were searched for fleas. Five or six white-toothed shrews, *Crucidura russula* (Hermann), caught in our garden at Tilburg were anaesthetized with ether before ectoparasites were removed from them. They were marked at the ears and released to be recaptured.

Rats were killed in and near farms and farm out-houses. Moles were collected in gardens and meadows. Squirrels, polecats, weasels and stoats were examined in a taxidermist's workshop at Oisterwijk. The taxidermist put all incoming animals in polythene bags and stored them in a deepfreeze until they were examined by the author. Three squirrels were shot by the author on the estate Villa Blanca, Goirle. These squirrels appeared to harbour the largest number of fleas per individual host in the present investigation.

Some mammal fleas were also collected from birds' nests while some bird fleas were recovered from the bodies of mammals especially of animals of prey.

Each animal was carefully searched for fleas and other ectoparasites by putting the contents of each bag into a deep white bowl and by brushing and blowing against the grain of the fur to remove parasites that had stayed on the dead hosts.

Bird fleas were collected from nests taken in the field. Only those nests of which the origin was certain were kept for incubation. Several bird watchers and foresters were of great help by showing nests of birds known to them.

The nests were put in separate polythene bags and kept at room temperature (18° C) for seven days. They were then carefully searched for fleas. The author is well aware of the fact that the nest material should have been kept for a longer period in order to obtain the maximum number of parasites that could possibly be bred from the pupae and maybe the larvae present. The shorter method was followed because of lack of time and space.

Often fleas were seen moving up the inside walls of the bags within a day or two. This happened always when a nest harboured many fleas. In such cases the contents of the bags were searched earlier, preferably daily, in order to prevent loss of fleas by drowning in the moisture accumulating on the inside walls of the bags. Sometimes fleas were seen in the nesting material directly after collection but usually they were not seen before incubation.

Fleas were picked up with a Leonhard forceps and stored in 70% alcohol until they were prepared for identification. The techniques used to mount the fleas

were those described by Smit (1957a) whose keys were also used for identification of the insects (Smit, 1954, 1957a, 1962a). For nomenclature of the mammals and the birds we followed Brink (1955), and Dobben (1963), respectively.

Results and Discussion

A. Mammals

In the discussion under every mammal or group of mammals some incidental remarks will be devoted to ecology and host specificity of the fleas occurring on them. The reader is advised also to read Smit (1962a) who gave a detailed account of every species of flea and a complete synopsis of "Host-flea-associations" recorded from The Netherlands until 1962.

Soricidae

Sorex minutus Linnaeus, the pygmy shrew. Tilburg, XI.1964—1 ♂, 2 ♀; 1 ♂, 1 ♀ infested. Fleas: *D. d. dasycnema* : 1 ♂; *P. s. soricis* : 1 ♂, 1 ♀.

Sorex araneus Linnaeus, the common shrew. Tilburg, X.1964 — 3 ♂, 4 ♀; 1 ♂, 1 ♀ infested. Fleas: *D. d. dasycnema* : 1 ♀; *P. s. soricis* : 2 ♂, 1 ♀; *C. b. heselhausi* : 1 ♂, 1 ♀.
Mill, XI.1964 — 1 ♂, 1 ♀; both infested. Fleas: *D. d. dasycnema* : 6 ♂, 3 ♀.
Vught, XII.1964 — 1 ♂, 1 ♀; 1 ♂ infested. Fleas: *D. d. dasycnema* : 1 ♂; *P. s. soricis* : 1 ♂.
Venlo, XII.1964 — 2 ♂; one infested. Fleas: *D. d. dasycnema* 1 ♂, 2 ♀; *P. s. soricis* : 1 ♀.

Crucidura russula (Hermann), the common European white-toothed shrew. Tilburg, XI.1964 — 2 ♂, 4 ♀; 1 ♂ infested. Fleas: *N. fasciatus* : 1 ♀.
Goirle, X.1964 — 1 ♂ examined and found infested. Fleas : *D. d. dasycnema* : 1 ♂, 1 ♀.
Oisterwijk, XII.1964 — 1 ♂, 1 ♀; 1 ♀ infested. Fleas: *P. s. soricis* : 1 ♂; *N. fasciatus* : 1 ♂, 1 ♀; *H. t. talpae* : 1 ♀.

Trapping of shrews was described in "Material and methods". All shrews caught in this way were found dead in the traps except for six shrews recorded from our garden at Tilburg. Pygmy shrews were trapped in pitfalls, which were not baited and in which the shrews were found dead. Of all fleas collected from the Soricidae examined, 55% were *D. d. dasycnema* and 26% *P. s. soricis.*

Palaeopsylla soricis soricis and *Doratopsylla dasycnema dasycnema* are host specific parasites of shrews. The latter species is a nest parasite and according to Smit (1962a) this may be one of the reasons why the species has not been collected much in the past. Moreover, shrews tend to harbour few fleas per individual host. Of the two specimens of *S. araneus* recorded from Mill the female carried seven specimens of *D. d. dasycnema*, an infestation worth recording. Remarkable is also that on the bodies of the hosts male specimens of this flea are more abundant than females. Smit (1962a) commented that the sex ratio is nearly

2 : 1 in favour of the males. Our figures agree very well with SMIT's observations.

Although *P. s. soricis* is a body flea rather than a nest dweller, we found few specimens of this species on the hosts examined.

C. b. heselhausi is a host specific mole flea and is particularly found in moles' nests. Shrews are recorded as accidental hosts for this flea as well as for the rat flea, *N. fasciatus*. Shrews are secondary hosts for the flea *H. t. talpae*. *N. fasciatus* has not been recorded before from shrews in The Netherlands, but SMIT (1957b) recorded it from *S. araneus* in the British Isles. SMIT (1962a) lists ten species of fleas found in association with shrews.

Crocidura russula was collected from live traps set out in three different localities. Unfortunately the specimens from our garden harboured only one *N. fasciatus* and no other species of fleas. Five of the six white-toothed shrews from the garden were marked and released. These were all recaptured sometimes twice a day for about a week. After that time they seemed to have disappeared from our garden where they had suddenly turned up. We had hoped to see whether *C. russula*, which occupied the same shelter places as *Mus musculus*, was liable to become infested with *Leptopsylla segnis*, the house-mouse flea, or possibly with other fleas that might have straggled into our garden on passing mammals. Although many house-mice were trapped, few were found infested and straggling onto *C. russula* did not occur, at least not during the short time we were able to recapture them.

All fleas, except *H. t. talpae*, recorded from *C. russula* examined by us are new host records.

Sorex minutus has not been recorded before as a host for fleas in this country and hence all species of fleas reported from them at Tilburg are new records. Our attempts to catch water shrews, *Neomys fodiens* Pennant, near ditches and ponds failed, nor did we succeed in trapping the bicolour white-toothed shrew, *Crucidura leucodon* (Hermann), which may occur in Noord-Brabant. No fleas have so far been recorded from *C. leucodon* in The Netherlands.

TALPIDAE

Talpa europaea Linnaeus, the mole.

Loon op Zand, X.1964 — 1 ♂, 1 ♀; 1 ♀ infested. Fleas: *P. minor* : 1 ♂, 2 ♂; *C. a. smitianus* : 1 ♂, 1 ♀.

St. Michiels Gestel, X.1964 — 1 ♂ examined and found infested. Fleas: *P. minor* : 1 ♀; *C. a. smitianus* : 1 ♂ 1 ♀; *H. t. talpae* : 1 ♀.

Mill, XII.1964 — 2 ♂, 1 ♀, all infested. Fleas: *P. minor* : 5 ♂, 3 ♀.

Tilburg, X.1964 — 2 ♂, 1 ♀; 1 ♂, 1 ♀ infested. Fleas : *P. minor* : 3 ♂, 3 ♀; *C. a. smitianus* : 1 ♂, 2 ♀; *P. s. soricis* : 1 ♂.

Vught, X.1964 — 2 ♂, 1 ♀, all infested. Fleas: *P. minor* : 4 ♂, 4 ♀; *C. a. smitianus* : 2 ♂, 3 ♀; *H. t. talpae* : 1 ♂; *M. turbidus* : 1 ♀.

SMIT (1962a) lists two host specific mole fleas, four secondary and nine accidental "flea-mole-associations". Of all fleas collected from moles by us, 62% belonged to the species *P. minor*. *C. a. smitianus* and *H. t. talpae* are often

found on moles, but they constitute only a secondary host-relationship. *M. turbidus* being a host specific vole flea must be regarded as a straggler when occurring on moles. *P. s. soricis*, a host specific shrew flea may also straggle onto moles. *C. b. heselhausi*, the second specific mole flea is a nest dweller and this may explain why it was not found by us. The host specificity of *P. minor* and *C. b. heselhausi* was wel demonstrated by Smit (1962b), who found that of the 13,330 fleas collected from 1,005 moles and 45 moles' nests at Wilp, Gelderland, The Netherlands, during a period of eleven years 90% of all fleas recovered from the moles and only 4.6% of all specimens retrieved from the nests were *P. minor* while 65.5% of all fleas taken from the nests and only 2.4% of all fleas gathered from the hosts were *C. b. heselhausi.* In Noord-Brabant *C. b. heselhausi* was recorded from Breda, where it was found in a mole's nest (Smit, 1962a). We record it from *S. araneus* at Tilburg.

Murinae

Apodemus sylvaticus (Linnaeus), the long-tailed field mouse.

Goirle, X—XI.1964 — 3 ♂, 5 ♀; 1 ♂, 3 ♀ infested. Fleas: *C. a. smitianus* : 2 ♂, 3 ♀.

Mill, XI.1964 — 6 ♂, 4 ♀; 5 ♂, 2 ♀ infested. Fleas: *T. poppei* : 9 ♂, 3 ♀; *C. a. smitianus* : 2 ♂, 2 ♀; *M. turbidus* : 2 ♂, 1 ♀; *N. fasciatus* : 2 ♀.

Oisterwijk, X.1964— 4 ♂, 4 ♀; 1 ♂, 1 ♀ infested. Fleas: *C. a. smitianus* : 1 ♂, 1 ♀; *M. turbidus* : 1 ♂, 1 ♀.

Tilburg, X—XI.1964 — 9 ♂, 5 ♀; 4 ♂, 4 ♀ infested. Fleas: *T. poppei* : 2 ♂, 2 ♀; *C. a. smitianus* : 1 ♂, 2 ♀; *M. turbidus* : 1 ♀.

Venlo, XII.1964 — 3 ♂, 1 ♀; 1 ♂, 1 ♀ infested. Fleas: *T. poppei* : 2 ♂, 1 ♀; *C. a. smitianus* : 1 ♀; *N. fasciatus* : 2 ♀; *C. g. gallinae* : 1 ♂.

A. sylvaticus is a very common mammal in The Netherlands where it inhabits nearly all terrestrial biotopes. It is the mammal par excellence for the study of fleas of small mammals occurring in an area because it attracts the great majority of species of mammal fleas, even those of which other small mammals are the principal hosts. The author found it possible to predict what species of mammals could be expected in a given area after examining a small number of flea-infested field mice. It was also found that mammals other than field mice were caught only after part of the population of the latter occurring around the spot where traps were set out had been trapped. This was also true for the bank vole, *Clethrionomys glareolus*, which as a rule enters traps before *A. sylvaticus*, whenever these two species share a habitat. *C. glareolus* is to some extent also a diurnal mammal and may therefore seem to be easier caught than *A. sylvaticus*. The common shrew, *Sorex araneus*, was never trapped before field mice and bank voles were captured. Although mice, voles and shrews live in close proximity, they seem to avoid each other in the open. It is therefore a good practice to leave traps for three or four consecutive days on the same spot rather than to keep moving them from one place to another after every night.

Many species of fleas have been found in association with field mice. Most of these relationships are of a secondary or accidental nature. *Typhloceras poppei* and

Ctenophthalmus agyrtes subspecies are regarded as the principal Siphonaptera found in association with this mammal. *Megabothris turbidus* appeared to be fairly common on the mice examined, but SMIT (1962a) regards *A. sylvaticus* as an accidental host for this flea, which has the bank vole, *C. glareolus*, for its principal host. Three specimens, two males and one female, of the subspecies *H. t. talpae* were found on a female field mouse caught on the estate Villa Blanca, Goirle. This mouse also carried one specimen of the subspecies *C. a. smitianus*. The record of the *Apodemus—H. t. talpae* association is new to The Netherlands (see discussion under *C. glareolus*). The occurrence of *Palaeopsylla minor*, a mole flea, on *Apodemus* is also a new host record. *N. fasciatus*, the rat flea, may often be found on small mammals whenever they share the same territory with rats so that exchange of fleas and other ectoparasites can easily be accomplished.

The bird flea *Ceratophyllus g. gallinae* was found on several mammals during our survey. This flea will feed on mammals when hungry, but its association with mammalian hosts must be regarded as accidental.

Special attention was paid as to whether the beetle *Leptinus testaceus* Müller (Col., Silphidae) occurred on *A. sylvaticus* or on any other small mammal or in birds' nests in Noord-Brabant and Limburg, but no specimen was found. The beetle was frequently found on field mice in Ireland (FAIRLEY, 1963b; CLAASSENS & O'ROURKE, 1964) and in Great Britain (J. BALFOUR BROWNE, British Museum, Natural History, personal communication). FAIRLY (1963b) reported that 15% of male and 4% of female *Apodemus* (138 specimens) taken in Co Down, Ireland, in October and November, 1962, harboured this beetle. We examined 109 field mice in Co Cork, Ireland, and found 12% of the males and 13% of the females infested with this beetle (CLAASSENS, 1964). KEER (1930) reported this beetle from The Netherlands as occurring on field voles, *Microtus arvalis*, on rats and long-tailed field mice. SMIT (personal communication) found it on *A. sylvaticus* in various parts of The Netherlands.

The beetle, which has also been recorded from nests of *A. sylvaticus* (O'MAHONY, 1945, 1947), from birds' nests (RYE, 1890; JOHNSON & HALBERT, 1902; LINSSEN, 1959; and CLAASSENS, 1964) and from the nests of *Bombus terrestris* (CUMBER, 1949), may also be found in rotten wood (LINSSEN, 1959) and in dead leaves (RYE, 1890). *L. testaceus* can be recognized by the long filiform antennae, and the absence of eyes. It is oval, small, 2 mm, very flattened, and dull testaceous in colour. It is still a matter of speculation as to whether the beetle has a parasitic, nidicolous or phoretic association with *A. sylvaticus*.

Rattus norvegicus (Berkenhout), the brown rat.

Cuyk, XII.1964 — 2 ♂, 3 ♀; 1 ♂, 1 ♀ infested. Fleas: *N. fasciatus* : 3 ♂, 5 ♀; *C. a. smitianus* : 2 ♂, 2 ♀.

Oisterwijk, XI.1964 — 3 ♂, 2 ♀; 2 ♂, 1 ♀ infested. Fleas: *N. fasciatus* : 1 ♂, 1 ♀; *C. a. smitianus* : 3 ♂, 2 ♀; *L. segnis* : 1 ♀.

Tilburg, XI.1964 — 1 ♂, 1 ♀, both infested. Fleas: *N. fasciatus* : 2 ♂, 3 ♀; *C. a. smitianus* : 1 ♂, 1 ♀; *C. b. heselhausi* : 1 ♂.

Venray, XII.1964 — 1 ♂, 2 ♀; 1 ♂, 1 ♀ infested. Fleas: *N. fasciatus* : 1 ♂, 4 ♀; *C. a. smitianus* : 1 ♂, 1 ♀.

Although the black rat, *Rattus rattus* (Linnaeus), and the brown rat, *R. norvegi-*

cus, occur in Noord-Brabant and Limburg, only the brown rat of more frequent occurrence was obtained during our survey. The abundance of the brown rat may be illustrated by some recent figures. A poultry farmer at Mill killed 407 rats in one day in a hen house (November, 1964); another caught 173 rats in one hen house also in one day (October, 1964) and a farmer at Tilburg killed 77 rats in October, 1964, also in a hen house. Many rats are killed too by poisoned bait; it is impossible to determine how many rats are killed daily by this method.

In addition to the damage they do to property of all kind, rats are vectors of diseases which they may disseminate to domestic animals and even to man. Some of these diseases are transmitted by ectoparasites, most important of which are the fleas.

Our observations revealed a predominance of *N. fasciatus* infestations on the rats examined. Although *N. fasciatus* is the common rat flea, it need not always be the predominant species of flea on rats in any area in Europe. Claassens & O'Rourke (1965) reported that of sixteen rats collected from four counties in Ireland only two carried *N. fasciatus* exclusively while all others were infested both with *N. fasciatus* and *Ctenophthalmus nobilis* (subspecies), or only with *C. nobilis* (subspecies). Of a total of 54 fleas collected from the 16 rats ten were *N. fasciatus* and all the other were either *C. nobilis nobilis* (Rothschild, 1898) or *C. n. vulgaris* Smit, 1955. Further investigations would be of interest. There may exist an interspecific competition between the species of the genus *Nosopsyllus* and those of the genus *Ctenophthalmus* when these species occur on rats occupying the same area.

Although Smit (1962a) listed nine species of fleas as being reported from brown rats in The Netherlands, we found only four, two of which were single specimens.

For the economic importance of rat fleas see the chapter on domestic and medical importance of fleas in this paper.

Mus musculus Linnaeus, the house mouse. Taken from our garden and house situated just outside the city boundary of Tilburg. Trapping of these mammals was started June 15th, and continued until December 15th, 1964. All mice were collected alive from the traps. The greater part (17 of 27 specimens) captured indoors were killed with a stick because they refused to enter traps. All other mice were caught in live traps baited with cheese. Mice of the outdoor population were grey brown on top and grey underneath while members of the indoor population had back and underside grey. Some of the mice killed indoors during November and December obviously belonged to the outdoor population.

Most of the mice were trapped near a small dump and in an aviary where they appeared to congregate after arriving in the garden. Trapping was started in June, but until September 15th only four mice were captured in the garden and three of these harboured fleas, while of the many mice obtained later very few fleas were recovered. Six shrews were also obtained from near the dump. For shrews see under Soricidae in this paper.

In table I details are given concerning the mice examined and their flea population. All mice taken during four weeks are put together in order to show the change in population density both of mice and their epi-fauna, as well as to demonstrate that species of fleas other than *Leptopsylla segnis* were removed only from those mice which visited our garden after August.

TABLE I. Fleas of *Mus musculus* Linnaeus

Details of the hosts				Details of flea population				
DATE	Locality	Number of mice examined	Number of mice infested	*Leptopsylla segnis*	*Ctenophthalmus agyrtes smitianus*	*Nosopsyllus fasciatus*	*Megabothris turbidus*	Total of fleas
1964	Tilburg	♂ ♀	♂ ♀	♂ ♀	♂ ♀	♂ ♀	♂ ♀	♂ ♀
June 15th.	indoors	1 3	1 2	7 10				7 10
July 15th.								
July 16th.	indoors	2 1	1 1	4 5				4 5
August 15th.	outdoors	1	1	2 2				2 2
August 16th.	indoors	3 5	2 2	4 7				4 7
Sept. 15th.	outdoors	1 2	1 1	1	1 0			2
Sept. 16th.	indoors	2 2	1 2	5 4				5 4
Oct. 15th.	outdoors	2 1	0 1			1 0		1
Oct. 16th.	indoors	2 0	2 0	3 4				3 4
Nov. 15th.	outdoors	22 13	4 1	2 1	1 1		1 0	4 2
Nov. 16th.	indoors	4 2	3 2	5 8				5 8
Dec. 15th.	outdoors	12 5	1 1	2 2		0 1		2 3
Total nos.....		52 34	17 13	35 43	2 1	1 1	1 0	39 45

Of the outdoor population (38 ♂ and 21 ♀) only 16% of ♂ and 19% of ♀ were infested with fleas, while of the indoor mice (14 ♂ and 13 ♀) and 70% and 70%, respectively, were infested. The remarkable difference may be explained by the fact that mice travelling from one place to another lose their ectoparasites. When searching for winter quarters mice may spend only a short time in the same hiding place and fleas which stay on the host only for a limited time to feed, are left behind.

Of the outdoor mice taken in August three of four specimens were infested, but two of these carrying fleas may have belonged to the local population of the garden where a stock of fleas may have been built up in their usual hiding places. The big invasion of mice took place during November, when 41 specimens were trapped. The last mouse was caught in the garden on December 10th. Trapping was continued until January 10th but not a single mouse could be trapped. Yet mice were sometimes seen during day-time. They seemed to have established a definite abode and as a result they might have regained their timidity and shyness. One female mouse was caught in the house on December 22nd, but it harboured no fleas.

The great predominance in the outdoor population of males over females is worth noticing. It would be of considerable interest to repeat such studies preferably during a longer period and with the aid of more traps.

It is the right place here to express sincere thanks to Messrs. H. van der Zande and H. Soetens who were of indispensable help in catching the specimens of *Mus musculus*.

Microtinae

Clethrionomys glareolus Schreber, the bank vole.

Goirle, X.1964 — 2 ♀, none infested.

Mill, XI.1964 — 2 ♂, 2 ♀; 1 ♂, 2 ♀ infested. Fleas: *C. a. smitianus* : 7 ♂, 6 ♀; *M. turbidus* : 1 ♀; *N. fasciatus* : 1 ♀.

Oisterwijk, X.1964 — 2 ♂, 1 ♀; 1 ♂, 1 ♀ infested. Fleas : *C. a. smitianus* : 1 ♂, 1 ♀; *M. turbidus* : 1 ♂.

Tilburg, X—XII.1964 — 11 ♂, 10 ♀; 10 ♂, 10 ♀ infested. Fleas : *P. silvatica* ; 4 ♂, 7 ♀; *C. a. smitianus* : 10 ♂, 8 ♀; *M. turbidus* : 1 ♂, 3 ♀; *C. c. congener* : 2 ♂, 3 ♀; *H. t. talpae* : 1 ♂, 1 ♀; *R. pentacantha* : 1 ♀.

Venlo, XII.1964 — 3 ♂, 3 ♀; 2 ♂, 1 ♀ infested. Fleas: *P. silvatica* : 3 ♂, 2 ♀; *C. a. smitianus* : 1 ♂; *M. turbidus* : 1 ♂, 1 ♀; *C. c. congener* : 1 ♀.

Though less common in some areas than the long-tailed field mouse, the bank vole is widely spread throughout The Netherlands. It avoids wet places and has a preference for deciduous woodlands, hedges, shrubs, edges of woods and may also occur in coniferous forests.

Ctenophthalmus agyrtes subspecies, *C. congener congener, Peromyscopsylla silvatica* and *Megabothris turbidus* are the principal fleas of *C. glareolus* in this country. With the exception of the subspecies *C. agyrtes* all these Siphonaptera were recovered from the bank voles examined. According to Smit (1962a), *C. glareolus*

is a secondary host for *C. a. smitianus*, but it was by far the most common species on the bank voles examined by us. For the geographical distribution of *C. a. agyrtes* and *C. a. smitianus* in The Netherlands see the synopsis of Dutch fleas in this paper and also SMIT (1962a).

H. t. talpae is a nest flea but it has been also found regularly on the bodies of mice, voles, moles and shrews. It is difficult therefore to determine the principal host of this largest of the European fleas. In Ireland *H. t. talpae* was often found on *A. sylvaticus* (FAIRLEY, 1963a; CLAASSENS & O'ROURKE, 1965). Moles are absent from Ireland and 18 voles, *C. glareolus,* examined there were not infested with this flea. For the discovery of the bank vole in Ireland see CLAASSENS & O'GORMAN (1965). The occurence of *N. fasciatus* on the bank vole is accidental, while the common bird flea, *Ceratophyllus g. gallinae,* is merely a straggler.

Rhadinopsylla pentacantha is usually found in association with *A. sylvaticus.* Its occurrence on *C. glareolus* is a new host record for The Netherlands. The record of *P. silvatica* is the second for The Netherlands. We took it also from a weasel, *Mustela nivalis,* shot at Oisterwijk. This Leptopsyllid mammal flea had been recorded before from Oldebroek (Gld.) where it was found on *C. glareolus* (SMIT, 1962a). SMIT commented that *P. silvatica* is not a very common parasite of voles but it has a wide distribution in Europe and a closely related subspecies, *P. silvatica spectabilis* (Rothschild, 1898) occurs in Great Britain and Spain.

Microtus arvalis Pallas, the common vole.

Cuyk, XII.1964 — 6 ♂, 8 ♀; 4 ♂, 4 ♀ infested. Fleas: *C. assimilis* : 3 ♂, 5 ♀; *C. a. smitianus* : 1 ♂, 3 ♀; *N. fasciatus* : 1 ♀.

Grave, XII.1964 — 5 ♂, 3 ♀; 3 ♂, 2 ♀ infested. Fleas: *C. assimilis* : 1 ♂, 1 ♀; *C. a. smitianus* : 1 ♂; *H. t. talpae* : 1 ♂.

Few fleas from the common vole, *M. arvalis*, have so far been examined. Special attempts were therefore made to catch these mammals. Although only four species of fleas on voles were found, the general trend of their flea infestation was well shown.

C. assimilis was the flea most commonly found on the 13 voles infested (59% of all fleas collected from them). *C. assimilis* is a host specific flea of the common vole (SMIT, 1962a). It appears to be a nest flea and is not often found in big numbers on the bodies of the hosts.

MUSTELIDAE

Mustela putorius (Linnaeus), the pole cat.

Oisterwijk, X—XI.1964 — 7 ♂, 5 ♀; 2 ♂, 1 ♀ infested. Fleas: *M. s. sciurorum* : 1 ♂; *A. e. erinacei* : 1 ♀; *C. a smitianus* : 1 ♂; *C. garei* : 1 ♂, 1 ♀.

Boxtel, X—XI.1964 — 5 ♂, 5 ♀; 1 ♂, 1 ♀ infested. Fleas: *C. a. smitianus* : 1 ♂; *C. g. gallinae* : 1 ♂.

Venray, X.1964 — 1 ♂ examined and found infested. Fleas: *M. s. sciurorum* : 1 ♂.

Mustela erminea Linnaeus, the stoat.

Oisterwijk, X—XI.1964 — 2 ♂, 1 ♀; 1 ♂ infested. Fleas: *M. s. sciurorum* : 1 ♂, 1 ♀; *C. garei* : 1 ♂.

Boxtel, XI.1964 — 1 ♂, 1 ♀; 1 ♂ infested. Fleas : *C. garei* : 1 ♀.

Mustela nivalis Erxleben, the weasel.

Oisterwijk, X—XI.1964 — 2 ♂, 2 ♀; 1 ♀ infested. Fleas : *A. e. erinacei* : 1 ♂, 2 ♂; *C. a. smitianus* : 1 ♀; *P. silvatica* : 1 ♂.

Mustela lutreola (Linnaeus) the european mink.

Tilburg, XI.1964 — nine nests examined, one infested. Fleas: *C. a. smitianus* : 2 ♂, 1 ♀.

The carnivores listed above are not usually infested with fleas. They acquire these parasites by preying upon small mammals and birds. Smit (1962a) lists several species of fleas recorded from these mammals, but the records of *C. a. smitianus, P. silvatica* and the bird fleas, *C. garei* and *C. g. gallinae*, are new to The Netherlands. Minks were never recorded before as accidental hosts for Siphonaptera in this country. We have investigated only some nests of these mammals when nest boxes were taken out of the cages on a mink farm. The mink farm was situated in a forest and fleas from the long-tailed field mouse or from the common shrew may have straggled onto these unusual hosts and from them into the nesting material.

C. a. smitianus was found most often on the carnivores examined. This is of course not surprising since many small mammals harbour this flea. Squirrel fleas were found on pole cats and stoats, but this is not unusual either, because squirrels abound in all areas where Mustelidae were captured.

Sciuridae

Sciurus vulgaris Linnaeus, the red squirrel.

Goirle, X—XI.1964 — 1 ♂, 2 ♀, all infested. Fleas: *M. s. sciurorum* : 55 ♂, 64 ♀; *C. g. gallinae* : 1 ♂, 1 ♀; *C. garei* : 1 ♀.

Oisterwijk, X—XI.1964 — 9 ♂, 6 ♀, 8 ♂, 6 ♀ infested. Fleas: *M. s. sciurorum* : 121 ♂, 113 ♀; *C. g. gallinae* : 1 ♀.

Boxtel, X.1964 — 3 ♂, 2 ♀, all infested. Fleas: *M. s. sciurorum* : 33 ♂ and 44 ♀; *C. garei* : 1 ♂.

Vugt, XI.1964 — 1 ♂ examined and found infested. Fleas: *M. s. sciurorum* : 1 ♂, 4 ♀.

Venray, X.1964 — 1 ♂, 1 ♀, both infested. Fleas: *M. s. sciurorum* : 78 ♂, 89 ♀.

Wanroy, XI.1964 — one nest. Fleas: *M. s. sciurorum* : 15 ♂, 19 ♀.

Beers, XI.1964 — two nests. Fleas: *M. s. sciurorum* : 12 ♂, 17 ♀.

The red squirrel, *Sciurus vulgaris*, is very common in most wooded areas in The Netherlands. Many specimens are shot every year in an attempt to keep their numbers in check and to decrease the damage done to the forests and bird fauna. Lack of natural predators, especially martens and wild cats made interference of man necessary. It is of interest to recall the records of the squirrel flea, *Monopsyllus sciurorum*, from the pole cat and stoat. These Mustelidae as well as the weasel appear to prey upon squirrels, but they seem to have little effect on the squirrel population.

M. s. sciurorum is the most common host specific squirrel flea in this country,

both on the bodies of the hosts and in their nests. This flea is often found in considerable numbers on squirrels and is said to be even more numerous in some nests. One of the squirrels shot on the estate Villa Blanca, Goirle, harboured 30 females and 24 males of this flea. *Tarsopsylla o. octodecimdentata*, another host specific squirrel flea, has been found in the provinces of Overijsel and Gelderland. It is a nest flea and is never found in large numbers on the host. SMIT (1962a) commenting on this flea noted that it is more frequently found in association with squirrels occupying territories in mountainous areas.

Of the squirrels' nests the two collected at Beers were newly built. The grass covering the inner lining of hay was still partly green. Though the number of fleas found in these nests was small, they provide an indication that transport of fleas from the bodies of the hosts to their nests occurs rapidly. The nests collected at Beers were so-called "winter nests".

The fleas *C. g. gallinae* and *C. garei* may have straggled onto squirrels from deserted birds' nests which are often visited by squirrels and may occasionally be used to store their food. No bird fleas were found in the squirrels' nests examined. The bird flea-squirrel-association must be very short-lived.

CHIROPTERA

SMIT (1962a) enumerated 11 species of bat fleas recorded from 13 species of bats. No bat flea was hitherto recorded from Noord-Brabant; from Limburg on the contrary nine bat fleas have been recorded in the past and nearly all were recovered from bats occupying the caves of South Limburg. *Nycteridopsylla eusarca* Dampf, 1908, and *Ischnopsyllus elongatus* (Curtis, 1832) are species of bat fleas not yet reported to occur in Limburg. Both the latter species are host specific parasites of the bat *Nyctalus noctula* (Schreber) which does not hibernate in caves.

In Noord-Brabant we found one male *Ischnopsyllus elongatus* on a female *Eptesicus serotinus* (Schreber) taken at Vught from a crevice in a wall, December, 1964; a female *Ischnopsyllus octactenus* (Kolenati) on a female *Pipistrellus pipistrellus* (Schreber) taken at Vught from a hole in a tree, December, 1964; one female *Ischnopsyllus hexactenus* (Kolenati) from the nest of a stock dove *Columba oenas* Linnaeus, which was situated in a hole in a wall under the eave of a house and one female of the same species from a female *Plecotus auritus* (Linnaeus) taken from a cellar, both records from Mill, December, 1964. Seven *Plecotus auritis* 5 ♂, 2 ♀) were taken from a farmhouse at Tilburg. These bats were not infested with fleas, nor could any fleas be bred from the debris gathered from under the roost.

Although bats have no nests, they have specific fleas; this can be explained by the fact that bats return to a definite roosting place to rest, sleep or hibernate. This habit, which provides conditions not unlike those in a bird's nest, suits the adult fleas, while the faeces of the bats, accumulating on the floor under the roots, ensure ideal food, shelter, temperature and humidity for the larvae of fleas and other ectoparasites.

Domestic Infestations

Man and domestic animals can act as hosts for several species of fleas, which if conditions are suitable may become annoying pests.

Fleas usually responsible for domestic infestations are *Pulex irritans* Linnaeus, the so-called human flea; *Ctenocephalides canis* (Curtis), the dog flea, and *Ctenocephalides felis felis* (Bouché), the cat flea. These species and subspecies were taken by the author on a farm at Oisterwijk, November, 1964, where a dog harboured 1 ♀ of *P. irritans* and 1 ♂, 1 ♀ of *C. canis*, two cats carried 2 ♂ of *P. irritans* and 1 ♂, 2 ♀ of *C. felis felis* and 1 ♀ of *C. canis,* and five specimens (3 ♂, 2 ♀) of *P. irritans* were collected from two pigs in December, 1964.

Another species of domestic importance is, as we have seen already, *Nosopsyllus fasciatus*, the rat flea. Of less domestic importance are the species *Leptopsylla segnis* (Schönherr), *Archaeopsylla e. erinacei* (Bouché) and *Spilopsyllus cuniculi* (Dale) and the bird fleas *Ceratophyllus g. gallinae* (Schrank).

There are not many recent records of rat flea infestations in houses. Smit (1962a) recorded a rat flea from a house. We obtained a rat flea from a mouse captured in our kitchen (see under *Mus musculus*). Claassens & O'Rourke (1965) reported a female *N. fasciatus* from a bed in a Cork suburb (Ireland).

L. segnis, the house mouse flea, feeds on man only when hungry; it could be contracted in rooms infested with house mice.

A. e. erinacei, the hedgehog flea has been recorded from cats and dogs and via these domestic animals it may be passed on to man. O'Rourke (1960) commenting on animal pets as reservoirs of zoonotic infections, noted that the hedgehog accumulates and excretes all strains of *Leptospira* available in an area. It is however, not known, whether fleas are capable of transporting *Leptospira* from animals to man. We obtained three females and one male of the subspecies *A. e. erinacei* from a dog which had been playing with a hedgehog (Tilburg, October 15th, 1964). The fleas were put back on the dog, which was re-examined on October 17th. Only one female flea could be found then and though it is not easy to find four fleas on a dog, we assumed that the parasites had left the unusual host. The obstinate female persevering in its accidental host relationship was kept for our collection. One female was also found on a pole cat and one male and two females were taken from a weasel (see under records of fleas from Mustelidae).

Two male and one female specimens of *S. cuniculi* were taken from 15 domestic rabbits of which only one was infested (Wanroy, November, 1964). One male was also taken from a rabbit trapped at Mill, November, 1964.

S. cuniculi is a semi-sedentary flea. It attaches usually to the innerside of the ears of rabbits and of accidental hosts such as cats, dogs and hares. Heavily serrated lacinia ensure a firm attachment. *S. cuniculi* is the principal vector of the Myxoma virus in Western Europe. This virus is transmitted purely mechanically by the infected mouth parts of the rabbit flea. Occasionally rabbit fleas may feed on man. Hunters, and people dealing with dead rabbits are most liable to contract these fleas.

Ceratophyllus g. gallinae, a very common bird flea has often been reported to infest hen houses and may occasionally be found on mammals. During our obser-

vations in Noord-Brabant and Limburg we found it on *Apodemus sylvaticus*, *Mustela putorius* and *Sciurus vulgaris*.

The ability of this flea to maintain itself in dry aerial nests may have guided it to hen coops where the egg-laying and roosting habits of the hens must suit the fleas very much. It has been proven that *C. g. gallinae* will breed when fed only on rat's blood. We used white mice to feed hundreds of specimens of this flea. In hen houses *C. g. gallinae* may become a real pest and may have a deleterious effect on the health and egg production of the fowl. Where hens, dogs and cats live in close proximity one will often find fleas straggling from fowl to mammals and via these to man. Man can also contract *C. g. gallinae* by cleaning infested hen houses.

MEDICAL IMPORTANCE

Fleas are hosts to a variety of organisms, several of which can be harmful to the fleas only while others may also be passed on to the fleas' hosts. In some cases such organisms may be passed on to man directy or via other hosts. *N. fasciatus, P. irritans, C. canis, C. f. felis* and *L. segnis* are potential carriers of the Plague bacteria, *Pasteurella pestis*. Some fleas act as intermediate hosts of cestodes of medical importance. The more common cestodes are *Hymenolepis nana* Siebolt, *Hymenolepis diminuta* Rudolphi and *Dipylidium caninum* Linnaeus. *Hymenolepis diminuta* is a parasite of rats and mice. Humans, especially children have been found infested too. The intermediate hosts of the tailed cysticercoids are the flour moth *Anisolabis annulipes* and the larval and adult forms of some beetles and the flea *N. fasciatus*. Human infestations are usually accomplished by consumption of fresh faeces of rats and mice (faecal contaminated food) and by consumption of insufficiently cooked bread stuff made from flour infested with grain insects.

H. nana is a parasite of rats and mice and even humans, especially children. Ingestion of ripe eggs of the cestode is possibly the commonest method by which humans, rats and mice become infested. There are a number of intermediate hosts in which the cysticercoid will develop and from them can be transferred to definite hosts. Important intermediate hosts are the fleas *C. canis, P. irritans* and some mealworms.

Dipylidium caninum is a cosmopolitan parasite of cats and dogs and may infest children occasionally. Intermediate hosts are *C. canis* and *P. irritans* as well as the dog louse *Trichodecta canis*. Dogs and cats infest themselves by eating infested fleas or lice. Children may be infested by accidentally eating infected fleas or lice, or cats and dogs may chew up the intermediate hosts and set free cysticercoids on to their coat or retain them in their mouth from where they can easily be passed on to man.

N. fasciatus is the most important vector of Endemic or Murine typhus. This disease is transmitted from rat to rat and other small mammals and from them to man by fleas. *C. canis* and *C. f. felis* have also been reported to be naturally infected with this disease and may therefore be potential carriers. *L. segnis* and possibly other fleas of small mammals are carriers of Murine typhus among their hosts and at times from these to man. The causative agent of Murine typhus is

Rikettsia mooseri which multiplies intracellularly in the fleas. Faeces of infected fleas are highly infectious. Human infestation is believed to occur when *Rikettsia* penetrate abraded skin at the sites of flea bites contaminated with flea faeces.

Two other diseases may possibly be transmitted to man by fleas: Tularemia and Salmonellosis. The etiological agent of Tularemia is *Pasteurella tularensis.* It has many vertebrate reservoirs and arthropod vectors, the most efficient ones being ticks which are often responsible for this disease in man. There is little in the epidemiology of Tularemia in man to suggest that fleas are important vectors. But fleas appear to play a definite part in transmission of Tularemia to animals, and man usually contracts Tularemia by handling infected mammals. Trappers and hunters are particularly liable to become infested. Tularemia is a plague-like disease, mainly affecting rodents in North-America, Japan, U.S.R.R., and several European countries. In man it has a mortality rate of four percent.

Salmonellosis has been transmitted experimentally to mice by the fleas *Xenopsylla cheopis* (Rothschild) and *N. fasciatus.* These fleas were infected with *Salmonella enteritides* and *S. typhimurium*, but only the former bacterium was transmitted and the exact mode of transmission was not determined. Regurgitation into the bite-wound of the host seemed probable.

For collateral reading on economic (domestic veterinary and medical) importance of fleas we refer to Jellison (1959), Lapage (1956 and 1957) and Rivers & Horsfall (1959).

Sex Ratios in Mammal Fleas

Significant numbers of specimens of fleas for a reliable determination of their sex ratios were obtained for *Ctenophthalmus agyrtes smitianus* (88 specimens, 50% males), *Leptopsylla segnis* (79 specimens, 45% males), *Monopsyllus s. sciurorum* (602 specimens on the bodies of the hosts, 48% males and 63 specimens from three nests, 43% males) and for *Nosopsyllus fasciatus* (31 specimens, 30% males).

The predominance of females among mammal fleas is usually pronounced. The highest ratio was found for *N. fasciatus.* Claassens & O'Rourke (1965) found 30% males among specimens of *N. fasciatus* collected in Ireland. Smit (1962b) reported that of 13,330 fleas collected from 1005 moles and 45 moles' nests the sex ratio for the former was 47% males and for the latter 38% males. Female fleas according to Smit may spend more time in the nests than males. Mead-Briggs & Page (1964) surmised that the predominance of female fleas on the bodies of hosts may be due to the greater need of nutriment for egg production. Since female fleas are more numerous both on the hosts and in their nests it is clear that at any stage in the adult state of fleas females outnumber the males. One exception may be *Doratopsylla d. dasycnema,* a host specific shrew flea for which the sex ratio for specimens on the bodies of the hosts is about 2 : 1 in favour of the males. See also sex ratios in bird fleas in this paper.

B. BIRD'S NESTS

Nearly 200 birds are known to breed in The Netherlands (SMIT, 1962a), but only 44 of these have so far been recorded as hosts of Siphonaptera. During our survey we found fleas of 13 unrecorded avian hosts' nests and for 13 other species of birds new host-flea-associations were found.

In the following synopsis of the material collected during the months of October, November and December, 1964, the newly recorded hosts and the newly recorded flea-host-associations have been marked with an asterisc. It can be used as a supplement to SMIT (1962a).

The localities from which nests of each species of birds (nests of 45 species of birds were examined) were collected are listed. After each locality the number of nests investigated and the number (in brackets) of nests found infested are given together with the number, sex and species of flea collected after incubation of the nests. The first figure under each species of flea indicates the number of male and the second figure indicates the number of female specimens obtained. All birds are listed under their respective families. For the nomenclature of the birds we have followed DOBBEN (1963). Subspecific names were only used for subspecies easily recognisable in the field.

TURDIDAE

Turdus merula Linnaeus, the blackbird.
Beers: 2(1), *Ceratophyllus g. gallinae* : 2, 3.
Goirle: 2(1), *C. garei* : 45, 60.
Mill: 5(2), nest 1: *C. garei* : 49, 56; nest 2: *C. g. gallinae* : 5, 3.
**Megabothris turbidus* : 0, 1.
St. Hubert: 6(1), *C. g. gallinae* : 2, 3.
Tilburg: 7(3), nest 1: *C. garei* : 80, 65; **C. fringillae* : 0, 1; nest 2: *C. garei* : 83, 127; *C. fringillae* : 11, 8; nest 3 : *C. g. gallinae* : 4, 7.
Wanroy: 2(1), *C. garei* : 52, 68; *C. g. gallinae* : 2, 3; **Dasypsyllus gallinulae gallinulae* : 2, 9.
Turdus ericetorum Turton, the song thrush.
Goirle: 2(0).
Mill: 3(1), *C. g. gallinae* : 2, 3.
St. Hubert: 1(1), **C. garei* : 2, 5.
Tilburg : 3(1), *C. g. gallinae* : 3, 7; **C. fringillae* : 1, 4.
**Turdus viscivorus* Linnaeus, the mistle thrush.
Mill: 1(1); *C. g. gallinae* : 1, 3.
Tilburg: 2(1), *C. garei* : 13, 17.
Wanroy: 2(1), *C. gallinae* : 15, 14; *C. fringillae* : 2, 5.
Phoenicurus phoenicurus (Linnaeus), the redstart.
Mill: 2(2), nest 1: *C. g. gallinae* : 9, 18; nest 2: *C. g. gallinae* : 4, 7; **C. fringillae* : 3, 6.

Erithacus rubecula (Linnaeus), the robin.
Mill: 1(1), **D. g. gallinulae* : 0, 1.
Goirle: 1(1), *C. garei* : 4, 5.

Fringillidae

Chloris chloris (Linnaeus), the greenfinch.
Mill: 1(1), **C. g. gallinae* : 15, 21; **C. garei* : 7, 8.
Fringilla coelebs Linnaeus, the chaffinch.
St. Hubert: 3(1), *C. g. gallinae* : 2, 5; **C. fringillae* : 0, 2.
Venray : 1(1), *C. g. gallinae* : 1, 1.
**Emberiza citrinella* Linnaeus, the yellow hammer.
Mill: 1(1), *C. garei* : 12, 14.
Beers: 2(1), *C. garei* : 1, 3; *C. g. gallinae* : 3, 7.

Troglodytidae

Troglodytes troglodytes (Linnaeus), the wren.
Tilburg: 3 (2), nest 1: *C. garei* : 5, 7; *D. g. gallinulae* : 1, 3; nest 2: *C. garei* : 15, 19.
Wanroy: 1(1), *C. g. gallinae* : 0, 3; **M. turbidus* : 0, 1; *Ctenophthalmus agyrtes smitianus* : 0, 1.

Prunellidae

Prunella modularis (Linnaeus), the hedge sparrow.
Mill: 1(0).
St. Hubert: 3(0).
Wanroy: 1(1), *C. g. gallinae* : 4, 5.
Tilburg: 2(1), *C. g. gallinae* : 5, 4; **C. garei* : 2, 3.

Motacillidae

Motacilla alba Linnaeus, the pied wagtail.
Goirle: 1(0).
Beers: 1(1), **C. garei* : 13, 20.
**Motacilla flava flava* Linnaeus, the yellow wagtail.
Tilburg: 1(1), *D. g. gallinulae* : 0, 1.

Paridae

Parus major Linnaeus, the great titmouse.
Mill: 1(1), *C. g. gallinae* 4, 7; *C. garei* : 0, 1.
Parus caeruleus Linnaeus, the blue titmouse.
Mill: 1(1), *C. g. gallinae* : 13, 12.
Venray: 1(1), *C. g. gallinae* : 1, 1.
**Aegithalos caudatus* (Linnaeus) the long-tailed titmouse.
Oisterwijk: 1(1), *C. g. gallinae* : 7, 13.

STURNIDAE

Sturnus vulgaris Linnaeus, the starling.
Goirle: 3 (0).
Mill: 4(1), *C. g. gallinae* : 2, 1.
Oisterwijk: 3 (2), nest 1: *C. g. gallinae* : 4, 6; nest 2: *C. fringillae* : 1, 3.

PASSERIDAE

Passer domesticus (Linnaeus), the house sparrow.
Oisterwijk: 3(2), nest 1: *C. gallinae* : 15, 17; nest 2: *C. gallinae* : 2, 7. *C. fringillae* : 2, 5.
St. Hubert: 2(1), *C. g. gallinae* : 7, 5.

PICIDAE

**Picus viridis* Linnaeus, the green woodpecker.
Tilburg: 1(1), *C. g. gallinae* : 3, 3; *Monopsyllus sciurorum* : 1, 2.
Oisterwijk: 1(1), *C. g. gallinae* : 0, 2; *C. garei* : 4, 7.

LARIDAE

**Chlidonias niger* (Linnaeus), the black tern.
Strabrechtsche heide, Witven: 10(1), *C. garei* : 3, 9.

RALLIDAE

Gallinula chloropus (Linnaeus), the moorhen.
Oisterwijk: 2(1), **D. g. gallinulae* 7, 12.
**Fulica atra* Linnaeus, the coot.
Strabrechtsche heide, Witven: 1(1), *C. g. gallinae* : 0, 2.

SYLVIIDAE

Acrocephalus scirpacetus (Hermann) the reed warbler.
Oisterwijk: 2(1), **D. g. gallinulae* : 1, 3; *C. garei* : 4, 5.

COLUMBIDAE

Columba livia domestica Linnaeus, the domestic pigeon.
Mill: 3(1),*C. gallinae* : 2, 2.
St. Hubert: 5(2), *Ceratophyllus columbae* : 1, 1; *C. g. gallinae* : 2, 2.
Tilburg: 7(1), *C. g. gallinae* : 5, 4.
Columba oenas Linnaeus, the stock dove.
Mill: 2(1), **C. g. gallinae* : 0, 2; **Ischnopsyllus hexactenus* : 0, 1.
Tilburg: 1(1), *C. g. gallinae* : 5, 9.

**Columba palumbus* Linnaeus, the wood pigeon.
Mill: 10(2), *C. columbae* : 1, 0; nest 2: *C. g. gallinae* : 0. 2.
Oisterwijk: 7(0).
Tilburg: 8(1), *C. g. gallinae* : 2, 2; *M. sciurorum sciurorum* : 1. 0.
**Streptopelia turtur* (Linnaeus), the turtle dove.
St. Hubert: 3(0).
Wanroy: 5(1), *C. g. gallinae* : 3, 1.
**Streptopelia decaocto* Friv., the collared dove.
Mill: 2(1), *C. g. gallinae* : 5, 8.
St. Hubert: 2(0).

Corvidae

Corvus frugilegus Linnaeus, the rook.
Wanroy: 1(1), *C. g. gallinae* : 4, 7.
**Pica pica* (Linnaeus), the magpie.
Schayk: 1(1), *C. g. gallinae* : 0, 1.
Corvus monedula Linnaeus, the jackdaw.
Tilburg: 3(1), *C. g. gallinae* : 17, 29.
**Garrulus glandarius* (Linnaeus), the jay.
Mill: 5(2), nest 1: *C. g. gallinae* : 0, 3; nest 2: *C. g. gallinae* : 1, 4; *M. s. sciurorum* : 1, 1.

Strigidae

**Tyto alba* (Scopoli), the barn owl.
Goirle: 4(1); *C. g. gallinae* : 0, 1; *C. a. smitianus* : 1, 1.

Falconidae

Accipiter nisus (Linnaeus) the sparrow hawk.
Beers: 1(1), *C. g. gallinae* : 0, 1; **C. garei* : 7, 5; **C. fringillae* : 1, 3.
**Falco tinnunculus* Linnaeus, the kestrel.
Goirle: 1(1), *C. g. gallinae* : 0, 3 (identification of nest doubtful, but kestrels were seen on the nesting site. Though this record is new to The Netherlands it wants reconfirmation).

Hirundinidae

Delichon urbica (Linnaeus), the house martin.
Goirle: 1(1), *Ceratophyllus hirundinis* : 51, 67; *C. rusticus* : 13, 9; *C. f. farreni* : 2, 5.
Schinnen: 2(2) nest 1: *C. hirundinis* : 209, 275; *C. rusticus* : 67, 110; nest 2: *C. hirundinis* : 97, 117; *C. rusticus* : 13, 19; *C. f. farreni* : 22, 29.
Hirundo rustica Linnaeus, the swallow.
Goirle: 1(0).

Mill: 5(1), *C. hirundinis* : 7, 5.
Tilburg: 3(0).
St. Michiels Gestel: 3(1); **Nosopsyllus fasciatus* : 0, 1.
Wanroy: 7(1): *C. g. gallinae* : 1, 5.

Riparia riparia (Linnaeus), the sand martin.
Mill: 3(3), *Ceratophyllus s. styx* : nest 1: 21, 29; nest 2: 54, 70; nest 3: 45, 59.
Venlo: 2(2), *C. s. styx* : nest 1: 13, 31; nest 2: 34, 47; *C. g. gallinae* : nest 2: 7, 13.

DISCUSSION OF NESTS INVESTIGATION

A total of nine species of bird fleas and five species of mammal fleas were collected from 204 nests of 45 species of birds. Not less than 77 nests (38%) were found to be infested. The number of fleas collected from individual nests was very variable. This of course was partly due to the ecological conditions prevailing in the nests after they were deserted by the birds. There may also be an interspecific difference in the reproductive capacity of fleas. *C. garei* and *C. g. gallinae*, as well as all martin fleas appear to be prolific breeders, while *D. g. gallinulae* and *C. fringillae* may have a less abundant offspring. Furthermore the main breeding season of bird fleas coincides with that of the bird hosts and hence the longer a nest is occupied either by adult or young birds the more favourable conditions are for the reproduction of fleas. Although most of the nests collected by us will have been occupied for at least some time by the hosts we have no idea about the duration of this occupation. The dry hot summer and our collecting of nests at random may be responsible for the moderate percentage of nests infested. ASH (1952) examined 109 nests of 23 species of birds in England and found that of 27 nests which had not contained young birds before they were deserted by the adults, 41% were infested; of eight nests which had contained young, but which were deserted by the adults before the young could leave, 50% were infested; of 66 nests from which young had fledged 56% were infested, and of eight nests which had contained eggs at one time but in which it was doubtful whether there had been young or not, 40% were infested. These figures show that the duration of occupation of nests by birds influences the degree of infestation.

The main difference in the percentage of infested nests examined by ASH and ourselves is due to the fact that we included 46 nests of tree-nesting birds which on the whole provide poor ecological requirements for ectoparasites to maintain themselves in these nests. Only ten of those 46 nests were found infested. Moreover, ASH collected birds' nests earlier in the year at a time that fewer fleas (larvae and pupae included) were lost through predation by enemies of fleas and through the activities of internal and external parasites. Taking all circumstances into account the percentage of infestation obtained by us may be considered rather high and it is an indication that by the majority of fleas hibernating is accomplished by survival as adult but especially as pupae in the hosts' nests. It would be of interest to examine a collection of birds' nests collected in February and March and compare the results.

Host Specificity in Bird Fleas

The species *C. hirundinis, C. rusticus, C. f. farreni* and *C. s. styx* are monoxenous parasites of the family Hirundinidae. *C. columbae* is a pigeon flea. The degree of humidity in the nests seems to determine whether any of the remaining four species of fleas will thrive or not. Since the situation of the nests is the chief factor determining the humidity one can conveniently divide birds' nests into the following four categories:

1, nests on or near the ground or otherwise in a wet position;

2, nests of bush nesting birds and nests built in positions providing the same degree of humidity. Nests in coniferous trees especially those in low position would belong to this group;

3, nests of hole nesting birds. The holes may be natural as well as artificial. Nests of sand martins, woodpeckers, tree creepers, as well as nests built in crevices of rocks and walls and those built in nest-boxes constitute this group;

4, nests of tree nesting birds. These nests are usually very dry, at least during the hot summer season. Many of these nests will be found uninfested particularly when little nest material is used. If such nests are infested the number of fleas present is often very small.

Sometimes nests built in holes may be very humid and this usually is reflected by large numbers of fleas occurring in them. Sand martin burrows for instance may be found teeming with fleas. Claassens (1965a) collected 1,742 specimens of the subspecies *C. styx jordani* Smit, 1956, from five sand martin burrows taken at Little Island, Co Cork, Ireland in July, August and October, 1963. From three starlings' nests situated in deserted sand martins' burrows 4,025 specimens of *C. g. gallinae* were collected at Ballycroneen strand, Ireland, in June and July, 1964 (Claassens & O'Rourke, 1965). None of these nests were incubated. These results prove that *C. g. gallinae* thrives very well in nests where the humidity is very high. On the other hand *C. g. gallinae* may be found in dry airy nests of pigeons. Rothschild & Clay (1952) commented that *C. g. gallinae* is the flea par excellence of dry aerial nests. Rothschild (1952) noted: "Despite the wide range of hosts, *C. g. gallinae* is much more common in nests of birds which are built in holes and at some distance from the ground". These statements seemingly contradictory in meaning indicate the wide range of tolerance of this flea to humidity. With Ash (1952) we would suggest that the nests of hole-nesting birds form a more congenial habitat for this flea than nests in a more exposed situation. But it is equally true that *C. g. gallinae* is often found in dry aerial situations. *C. g. gallinae* shares humid nests with *C. garei* and *D. g. gallinulae*, two species commonly infesting the nests of ground and bush nesting birds, provided these nests are not dry. On the other limit of tolerance to humidity *C. g. gallinae* is often found in company with *C. fringillae* and *C. columbae*, two species of flea which seem to prefer the dryer types of nests. To the former group we may add the rare Dutch flea *Ceratophyllus borealis* Rothschild, 1907, which in its distribution seems to be restricted by climatic and geological conditions. The group *gallinae, fringillae* and *columbae* may be extended with the

equally rare flea *Ceratophyllus r. rossittensis* Dampf, 1913, which is a monoxenous parasite of the crow, *Corvus corone* Linnaeus.

In table II, avian hosts are classified according to the four categories of nesting sites mentioned above. After each species of bird the number of nests examined from each nesting site and the number (in brackets) of nests infested are given. The host specific fleas of the Hirundinidae and the species *C. columbae* in nests of pigeons are omitted. Some nests of black birds are classified under different categories because these nests were found in a variety of situations. Under each species of flea recorded, the number of specimens found in the total number (in brackets) of nests infested with that flea are given.

One should be aware of the fact that any classification of this kind is very artificial because nests can be dry or wet in any of the four situations depending upon accidental local ecological circumstances.

Table II. Distribution of nests and their flea population with regard to the nest situation

Details of nests examined		Details of flea population				
Host species	No. of nests examined and infested	*Ceratophyllus garei*	*Dasypsyllus gallinulae gallinulae*	*Ceratophyllus gallinae gallinae*	*Ceratophyllus fringillae*	Total of fleas
Ground						
Turdus merula L. (in ivy) . .	3 (3)	460 (3)	—	—	20 (2)	480
Emebriza citrinella L.	3 (2)	30 (2)	—	10 (1)	—	40
Troglodytes troglodytes (L.) .	4 (3)	46 (2)	4 (1)	3 (1)	—	53
Motacilla flava flava L. . . .	1 (1)	—	1 (1)	—	—	1
Chlidonias niger (L.)	10 (1)	12 (1)	—	—	—	12
Gallinula chloropus (L.) . . .	2 (1)	—	19 (1)	—	—	19
Fulica atra L.	1 (1)	—	—	2 (1)		2
Bush						
Turdus merula L.	21 (6)	225 (2)	11 (1)	34 (5)	—	270
Turdus ericetorum Turton . .	9 (3)	7 (1)	—	15 (2)	5 (1)	27
Turdus viscivorus L.	5 (3)	20 (1)	—	33 (2)	7 (1)	60
Erithacus rubecula (L.) . . .	2 (2)	9 (1)	1 (1)	—	—	10
Chloris chloris (L.)	1 (1)	15 (1)	—	36 (1)	—	51
Fringilla coelebs L.	4 (2)	—	—	9 (2)	2 (1)	11
Prunella modularis (L.) . . .	7 (2)	5 (1)	—	18 (2)	—	23
Aegithalos caudatus (L.) . . .	1 (1)	—	—	20 (1)	—	20
Acrocephalus scirpaceus (Herman)	2 (1)	9 (1)	4 (1)	—	—	13
Phylloscopus collybita (Vieillot)	1 (0)	—	—	—	—	—
Holes						
Phoenicurus phoenicurus (L.) .	2 (2)	—	—	38 (2)	9 (1)	47
Muscipata striata (Pallas) . .	1 (0)	—	—	—	—	—

Table II (continued)

Details of nests examined		Details of flea population				
Host species	No. of nests examined and infested	*Ceratophyllus garei*	*Dasypsyllus gallinulae gallinulae*	*Ceratophyllus gallinae gallinae*	*Ceratophyllus fringillae*	Total of fleas
Motacilla alba L.	2 (1)	33 (1)	—	—	—	33
Parus major L.	1 (1)	1 (1)	—	11 (1)	—	12
Parus caeruleus L.	2 (2)	—	—	27 (2)	—	27
Parus palustris L.	1 (0)	—	—	—	—	—
Sturnus vulgaris L.	10 (3)	—	—	13 (2)	4 (1)	17
Passer domesticus (L.)	5 (3)	—	—	53 (3)	7 (1)	60
Passer montanus (L.)	2 (0)	—	—	—	—	—
Picus viridis L.	2 (2)	11 (1)	—	8 (2)	—	19
Columba livia domestica L.	15 (4)	—	—	17 (3)	—	17
Columba oenas L.	3 (2)	—	—	16 (2)	—	16
Tyto alba (Scopoli)	4 (1)	—	—	1 (1)	—	1
Falco tinnunculus L.	1 (1)	—	—	3 (1)	—	3
Riparia riparia (L.)	5 (5)	—	—	20 (1)	—	20
Hirundo rustica L.	19 (3)	—	—	6 (1)	—	6
Corvus monedula L.	3 (1)	—	—	46 (1)	—	46
Trees						
Columba palumbus L.	25 (3)	—	—	6 (2)	—	6
Streptopelia turtur (L.)	8 (1)	—	—	4 (1)	—	4
Streptopelia decacto Friv.	4 (1)	—	—	13 (1)	—	13
Corvus frugilegus L.	1 (1)	—	—	11 (1)	—	11
Pica pica (L.)	1 (1)	—	—	1 (1)	—	1
Garrulus glandarius (L.)	5 (2)	—	—	8 (2)	—	8
Accipiter nisus L.	1 (1)	12 (1)	1 (1)	1 (1)	4 (1)	17
Asio otus (L.)	1 (0)	—	—	—	—	—
Total nos.	177 (65)	895 (19)	41 (7)	482 (48)	58 (9)	1466
Average fleas per nest infested	—	47	6	10	7	—

is rarely found in large numbers, but *C. g. gallinae* may be present by hundreds in one single nest as we have shown earlier. Many specimens may sometimes also be bred from the nests. The author bred 1,064 specimens from one nest of a blue tit, *Parus caeruleus,* situated in a hole in a wall at Blarney, Co Cork, Ireland (Claassens & O'Rourke, 1965). On the days of collection, June 2nd, 1964, the nest contained only one female *D. g. gallinulae.* During incubation, which lasted from June 2nd until July 6th only five additional males and six females of *D. g. gallinulae* were obtained. Ash (1952) obtained 1,304 *C. g. gallinae* from a blue tit's nest.

From table II it may be seen that the average number of fleas per infested nest is rather low for the subspecies *D. g. gallinulae* and *C. g. gallinae. D. g. gallinulae*

D. g. gallinulae seems to be fairly scarce in The Netherlands, where it has so far been found in five provinces. SMIT (1962a) commented that this species should be commonly present here as it is found in abundance in surrounding countries. We investigated 53 nests situated in bushes and hedges but we found that only three of these harboured *D. g. gallinulae*. Of 24 nests collected on or near the ground only three contained this species. *D. g. gallinulae* may experience a good deal of competition from *C. garei* which appeared to be very common in the nests of both ground- and bush nesting birds. *C. garei* shares humid nests with *C. g. gallinae* too and may thus also be responsible for the relative scarcity of the latter species.

C. fringillae prefers dryer nests of the house sparrow, *Passer domesticus*, and starlings, *Sturnus vulgaris*, as well as the dry nests of other Passerine birds. Strangely enough we found 19 specimens in a very humid nest of a blackbird which was situated in ivy against a stone wall. It may be that this population of *C. fringillae* originated in the nest of a spotted fly catcher, *Muscicapa striata*, which reared young in the same ivy the year before. Its presence in the nest of a sparrow hawk, *Accipiter nisus*, may have been the result of predation.

ROTHSCHILD (1958) found a seasonal variation with regard to the species of fleas infesting birds (migrants and residents) on Fair Isle. In spring 66% of all fleas found on migrant and resident birds were *D. g. gallinulae* and 16% were *C. g. gallinae* but in autumn the situation was reversed and *C. g. gallinae* became by far the most common species both on residents as on migrant species. ROTHSCHILD suggested that the main dispersal period of *D. g. gallinulae* (and *C. borealis*) is the spring and of *C. g. gallinae* the summer and autumn. Indeed in summer *C. g. gallinae* may be found teeming in birds' nests. CLAASSENS & O'ROURKE (1965), as was mentioned already, collected 4,025 specimens of this flea from three starlings' nests in June and July (1964) and 1.064 specimens were bred from a blue tit's nest during June, 1964.

Very few adult fleas were found by the author in the nests collected in Noord-Brabant and Limburg. It seems likely that adult fleas leave the hosts' nests after the young birds have left in late summer or earlier. These manoeuvres undoubtedly increase the survival chances and dispersal of fleas. ROTHSCHILD (1958) found that spring migrants (199 specimens) had an infestation rate of 52,2% as compared with 2,7% of 615 autumn migrants. It may be that in autumn fleas are more active in searching for a sheltered place to hibernate while in spring they may become very eager to find a host.

SEX RATIOS IN BIRD FLEAS

In Table III the numbers of either sex of bird fleas collected and the percentages of males among them are listed. Some of the results are compared with those obtained by CLAASSENS & O'ROURKE (1965) for the same species collected in Ireland and with those obtained by ASH (1952) for specimens taken in England. The percentages of males among martin fleas are compared with results published by CLAASSENS (1965b), who studied these fleas in Ireland, and with those recorded by THOMPSON (1952; 1953) from Engeland and with the ones

TABLE III. Percentages of males among the total number of fleas from Noord-Brabant and Limburg, compared with those obtained for the same species elsewhere

Species of fleas examined	Number of males and females and percentages of male specimens in the present collection of fleas			The total number of specimens and percentages of males collected elsewhere					
	♂	♀		Claassens 1965	Claassens & O'Rourke 1965	Ash 1952	Thompson 1952 & 1953	Dunnet & Allan 1954	average percentage male specimens
C. garei	394	501	44%	-	-	45%	-	-	44.5%
D. gallinulae	11	29	28	-	27% (137)	44% (835)	-	-	33%
C. gallinae	190	292	39%	-	45% (2071)	46% (2201)	-	-	43%
C. fringillae	21	37	38%	-	-	-	-	-	38%
C. hirundinis	364	464	44%	39% (655)	-	-	-	38% (781)	41%
C. rusticus	93	138	40%	44% (390)	-	-	-	48% (2913)	44%
C. farreni	24	34	41%	37% (667)	-	-	-	43% (834)	40%
C. styx jordani	167	236	41%	46% (1709)	-	-	45% (2311)	-	44%

recorded by DUNNET & ALLAN (1954) of martin fleas collected in Scotland. The figures pertaining the subspecies *C. s. styx* are compared with those of *C. s. jordani* Smit, 1955, collected in Ireland and with the percentages known for the species *C. styx* collected in England.

The species *C. columbae* is omitted as too few specimens were found. No comparative results were available for *C. fringillae.*

In bird fleas there is a definite predominance of females. Although with some species there is a wide range of variation in the percentages of the sexes recorded by diverse authors it seems likely that the average percentages shown in Table III will be close to the prevailing situation in the nests of the hosts. ROTHSCHILD (1958) found a gradual increase of females on the birds of Fair Isle from spring until autumn. There was, however, a preponderance of male *D. g. gallinulae* on spring passage migrants. In July there was an excess of females on resident birds and on September and autumn migrants only females were found. In the nests of the Fair Isle birds ROTHSCHILD found a six percent majority of female *D. g. gallinulae.* Both the predominance of males of *D. g. gallinulae* on spring passage migrants and the low sex ratio of these fleas in the nests of the hosts are very unexpected and should make a rewarding object of further investigation. Females of *C. g. gallinae* outnumbered males both in the nests and on the bodies of the birds of Fair Isle, but on the hosts there was a gradual increase of females.

ROTHSCHILD (1958) drew the attention to the low ratio 48—50 in favour of female *C. g. gallinae* found in the nests of the common resident bird, the wheatear, *Oenanthe oenanthe* (L.), CLAASSENS & O'ROURKE (1965) reported an exceptional ratio 200 : 114 in favour of males in *C. g. gallinae* taken from a starlings' nest collected at Ballycroneen strand, Ireland, in June, 1964. We do not know what ecological or genetic factors favour an unusual high production of males or result in the survival of more males than females.

The apparent predominance of females among adult fleas is no indication that fewer male flea embryos should be produced (primary sex ratio), nor that fewer male fleas hatch from cocoons (secondary sex ratio). Numerical preponderance of females may well develop in later stages of adult fleas. A collection of fleas from birds' nests taken in February and March might well reveal a still higher sex ratio in favour of females. Females seem to outlive males by many months and can withstand adverse conditions to which males succumb. Males of many species of fleas are believed to die soon after copulation. A gradual increase of female fleas seems therefore natural especially on the bodies of the host since, after copulation, females lay eggs in batches, and each time before a fertile batch is laid the female reproductive organs require the stimulus of a blood meal (ROTHSCHILD & CLAY, 1952).

The greater hardiness of females may sometimes be responsible for their great predominance in collections made under artificial laboratory conditions. A predominance of females was also found among stragglers of mammal flea species to birds' nests. Of five species of mammal fleas collected from birds' nests discussed here we found that of a total of 13 specimens nine were females. MEAD-BRIGGS & PAGE (1964) found that of 56 fleas other than *S. cuniculi* which were found as

stragglers on 30 out of 279 rabbits obtained throughout Great Britain, 38 were females and they noted that similar results were recorded previously from Kent.

Summary

Nineteen species of mammals (336 specimens) and 204 nests of 45 species of birds were examined for fleas. In total 954 specimens (23 species) of mammal fleas and 12 specimens (2 species) of bird fleas were collected from the bodies of 174 mammals infested, while 63 specimens of the subspecies *Monopsyllus s. sciurorum* (Schrank), were taken from three nests of the red squirrel, *Sciurus vulgaris* Linnaeus.

From 77 birds' nests found infested 2.997 specimens (nine species) of bird fleas were reared and 13 specimens (five species) of mammal fleas were obtained.

All this material was collected in the provinces of Noord-Brabant and Limburg, The Netherlands, mainly during the months of October, November and December, 1964.

Fifteen mammal fleas and five bird fleas were found to be new to Noord-Brabant and two mammal fleas and four bird fleas could be added to the list of Siphonaptera of Limburg. Thirteen species of birds and two species of mammals, viz. *Sorex minutus* Linnaeus and *Mustela lutreola* (Linnaeus) were added to Smit's (1962a) lists of hosts for Dutch fleas. For 23 flea hosts recorded in Smit (1962a) new flea-host-associations were found.

The ecology, host- and nest specificity, sex ratios and economic importance (domestic infestations, veterinary and medical importance) of fleas were discussed.

In a synopsis of Dutch fleas every species is followed by the names of the provinces from which it was recorded by Smit (1962a) and our records for Noord-Brabant and Limburg were added and marked with an asterisc.

Mammal fleas were dealt with under the relevant mammalian hosts examined. Bird fleas were first listed in a synopsis of material collected so as to make exact recording possible. In a further discussion of these fleas special attention was paid to their host or nest site specificity.

Sex ratios in bird fleas were compared with results recently obtained by the author and by other students of fleas.

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